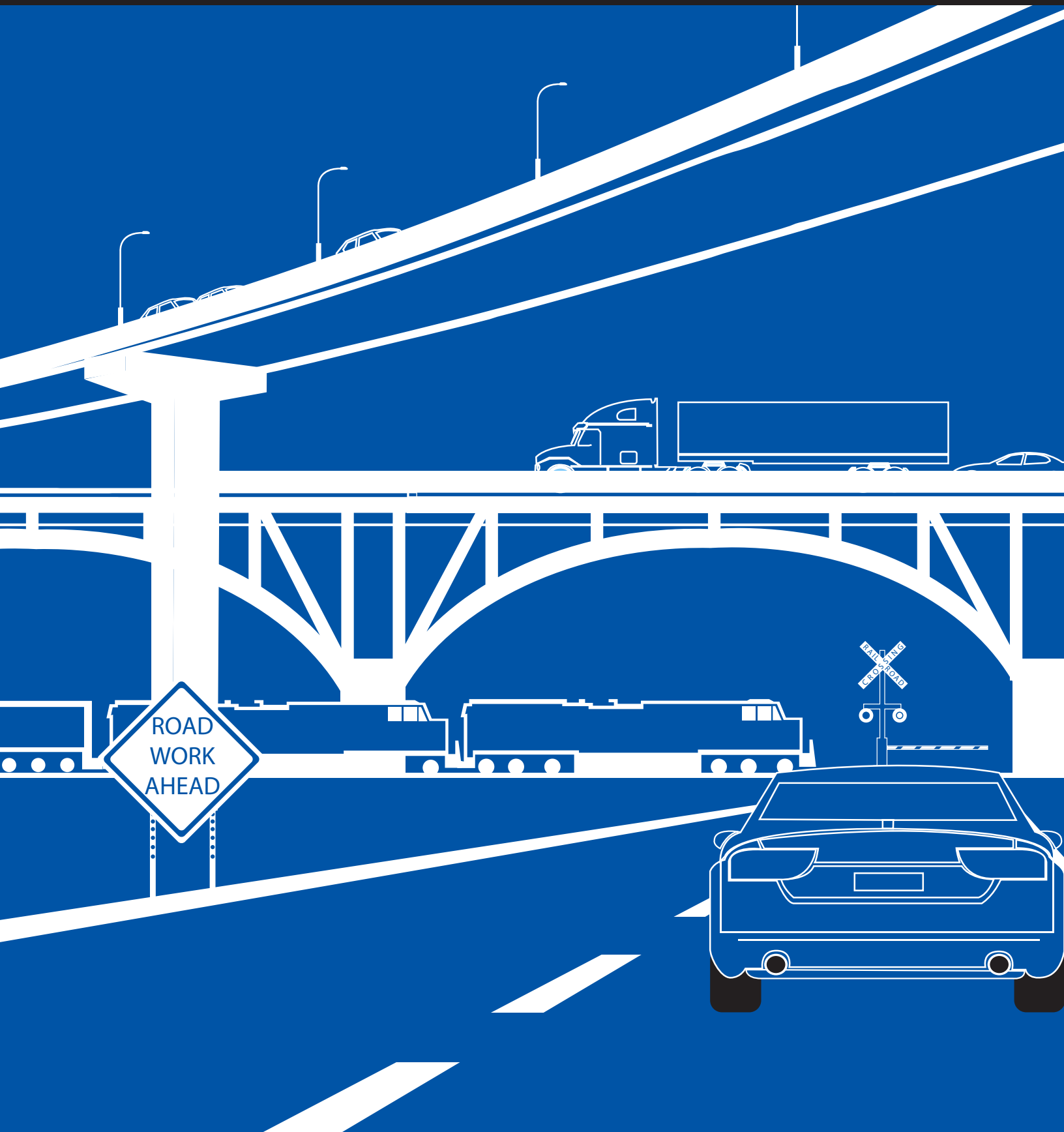
Development of a Research Project Tracking System

Report Number: KTC-17-01/SPR14-491-1F

DOI: https://doi.org/10.13023/ktc.rr.2017.01



Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

KTC KENTUCKY Transporation Center

Kentucky Transportation Center • University of Kentucky
176 Raymond Building • Lexington, KY 40506 • 859.257.6898 • www.ktc.uky.edu

University of Kentucky

Research Report
KTC-17-01/SPR14-491-1F

Development of a Research Project Tracking System

Joseph D. Crabtree, Ph.D., P.E.
Director, Kentucky Transportation Center

and

Bradley A. Rogers
Research Associate

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, KY

in cooperation with the
Kentucky Transportation Cabinet

March 2017

1. Report No. KTC-17-01/SPR14-491-1F	**2. Government Accession No.**	**3. Recipient's Catalog No**
4. Title and Subtitle Development of a Research Project Tracking System		**5. Report Date** March 2017
		6. Performing Organization Code
7. Author(s): Joseph D. Crabtree and Bradley A. Rogers		**8. Performing Organization Report No.** KTC-17-01/SPR14-491-1F
9. Performing Organization Name and Address Kentucky Transportation Center College of Engineering University of Kentucky Lexington, KY 40506-0281		**10. Work Unit No. (TRAIS)**
		11. Contract or Grant No. SPR 14-491
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, KY 40622		**13. Type of Report and Period Covered**
		14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the Kentucky Transportation Cabinet and the Federal Highway Administration

16. Abstract
The Kentucky Transportation Center, in cooperation with the Kentucky Transportation Cabinet, has developed a Research Project Tracking System (RPTS). The RPTS is web-based and includes a database of active (and recently completed) research projects. The system allows authorized users to access and edit the project data, enter new projects into the system, and produce periodic progress reports. It produces a homepage (or dashboard) for each project, and it provides links to key project documents. It also has the capability to track the implementation of research results on a project-by-project basis.

17. Key Words State Planning and Research (SPR), Online Project Management, Research Implementation, Database Development, Tracking Systems		**18. Distribution Statement** Unlimited with permission of the Kentucky Transportation Cabinet and the Kentucky Transportation Center	
19. Security Classification (report) Unclassified	**20. Security Classification (this page)** Unclassified	**21. No. of Pages** 39	**22. Price**

Table of Contents

List of Figures

List of Tables

Acknowledgements

The following individuals contributed greatly to the successful completion of this project through their participation on the Study Advisory Committee.

- Jason Siwula (Chair) – Kentucky Transportation Cabinet
- Jeffrey Hill – Kentucky Transportation Center
- Bob Lewis – Kentucky Transportation Cabinet
- Paul Looney – Kentucky Transportation Cabinet
- John Moore – Kentucky Transportation Cabinet
- Randy Stull – Kentucky Transportation Cabinet
- Tony Young – Federal Highway Administration, Kentucky Division

Executive Summary

The Kentucky Transportation Cabinet (KYTC) manages a vital and active research program, with the research being conducted by the Kentucky Transportation Center (KTC) at the University of Kentucky. At any given time, the program will entail fifty to sixty active projects funded through the State Planning and Research (SPR) Program. In addition, the Center also carries out a variety of projects funded from other sources, such as Kentucky Highway Investigative Tasks (KHITs), Federal Research Tasks (FRTs), Office of Highway Safety projects, Planning Studies, and Research Study-Federal (RSF) projects. KYTC's Research Program has functioned successfully for many years, and individual projects are generally well-managed and successful. However, there has not been a centralized database of all projects, and no capability has existed for online progress reporting. Quarterly progress reports are generated for SPR projects, but these reports provide limited information and they stop when the project is completed. Hence, there is no method to track the implementation of research on a project-by-project basis. There is also no straightforward way to locate and access important project files, making it difficult to have a clear understanding of what is going on across the research program and promoting inconsistency in project management practices. As a result, those responsible for managing the research program are hindered in their ability to access project information and to provide oversight and effective management for the entire program.

KYTC decided in 2013 that a centralized, online project tracking system was needed for all research projects. The objective of this project was to develop and implement a web-based project management tool for research projects. This tool would provide easily-accessible, up-to-date information on project accomplishments and milestones, the current status of each project, and quick links to key project documents and deliverables. In addition to tracking the progress of active projects, the system would track and report the implementation of research results, following project completion.

Prior to beginning the development of the Research Project Tracking System (RPTS), the project team identified "benchmark" systems in other states. Information was obtained from Louisiana, Minnesota, Washington, North Carolina, Illinois, Texas, Virginia, and the Turner-Fairbank Highway Research Center of the Federal Highway Administration. While none of the benchmark systems were deemed to be directly adaptable to Kentucky's needs, they were extremely valuable in identifying functionality and features that would be incorporated into the system design for the RPTS.

The first step in the RPTS development was producing a list of required and desired functionalities. This list was developed, refined, and approved by the project's Study Advisory Committee (SAC). Based on this list, a preliminary system design was developed and captured in a series of webpage mockups. A web developer/programmer was hired in May of 2015 and immediately went to work on the system development. By July of that year, the prototype system was operational and was populated with project data. A preliminary evaluation was conducted over the next seven months, resulting in a list of changes that were either required or desired.

The implementation of system enhancements was a continuous process throughout the preliminary evaluation period and for the two months thereafter. Once the identified enhancements were

implemented, the final evaluation was conducted in April through July of 2016. At that point, the RPTS was considered complete, although a punch-list was developed to document possible future enhancements.

1. Introduction

The Kentucky Transportation Cabinet (KYTC) manages a vital and active research program. The research is conducted by the Kentucky Transportation Center (KTC) at the University of Kentucky, under a longstanding research agreement. A large portion of the research program is funded and administered under the research portion of the State Planning and Research (SPR) Program. Fifteen to twenty new projects typically will be started each year, and the number of active projects at any given time is typically between fifty and sixty. Each project has a Principal Investigator, a Study Advisory Committee (SAC), and a designated SAC Chair. Oversight and direction for each project is provided by the respective SAC, while KYTC's Research Coordinator provides oversight and guidance for the overall program. In addition to the SPR projects, the Center also carries out a variety of projects funded from other sources, such as: Kentucky Highway Investigative Tasks (KHITs), Federal Research Tasks (FRTs), Office of Highway Safety projects, Planning Studies, and Research Study-Federal (RSF) projects.

1.1 Problem Statement

KYTC's Research Program has functioned successfully for many years, and individual projects are generally well-managed and successful. However, those responsible for managing the program have never had a centralized system for storing and accessing information on all projects, and no capability has existed for online progress reporting. Kentucky tracks SPR projects through the use of periodic (i.e., quarterly) progress reports, which are prepared by the Principal Investigators, compiled by KTC's front office, and emailed to KYTC's Research Coordinator. This system relies on distributing the reports electronically to everyone who may need to see them, and there is a limited amount of information that can be provided via these one-page reports. These progress reports cease when the project is completed, and there is no method to track the implementation of research on a project-by-project basis. There is also no straightforward way to locate and access other important project files, such as new-project approval requests, project approval sheets, approved work plans, implementation plans, meeting agendas and minutes, interim reports, prior status reports, and other crucial documents. This makes it difficult to have a clear understanding of what is going on across the program, and promotes inconsistency in project management practices from project to project and from investigator to investigator. As a result, the Cabinet's Research Coordinator and other key stakeholders are hindered in their ability to access project information and to provide oversight and effective management for the entire program.

In response to these needs, KYTC decided in 2013 to begin the development of a centralized, online project tracking system for all research projects.

1.2 Project Objective

The objective of this project was to develop and implement a web-based project management tool for research projects. This management tool was intended to provide easily accessible, up-to-date information on project accomplishments and milestones, the current status of each project, and quick links to key project documents and deliverables. In addition to tracking the progress of active projects, the system would be capable of tracking the implementation of research results following project completion.

1.3 Project Tasks

The following tasks and milestones were identified for the accomplishment of the proposed research:

Task 1: Identify "benchmark" states having effective online project management systems. Gather and review information on those systems to identify capabilities, strengths, weaknesses, and lessons-learned for Kentucky.

Milestone #1: Memorandum report summarizing the information gathered on the systems of the benchmark states. (Deliverable)

Task 2: With input from key project stakeholders, develop list of required and desired features and capabilities for Kentucky's system.

Milestone #2: Approved list of required and desired features and capabilities. (Deliverable)

Task 3: Develop prototype system and implement it for a selected sample of projects.

Milestone #3: Prototype system operational and information populated for a selected sample of projects.

Task 4: Evaluate prototype system and identify needed/desired changes.

Milestone #4: List of needed/desired changes from preliminary evaluation. (Deliverable)

Task 5: Implement and test changes. Ensure that testing is performed on data for both SPR and non-SPR projects.

Milestone #5: Needed changes (and desired changes, to the extent practical) implemented and tested.

Task 6: Perform an additional three months of system evaluation.

Milestone #6: Memorandum report summarizing findings of evaluation and recommendations for future enhancements. (Deliverable)

Task 7: Prepare and deliver final report.

Milestone #7: Final Report (Deliverable)

2. Identifying and Assessing "Benchmark" Systems (Task 1)

Both the Principal Investigator and the SAC Chair for this project serve as members of the Research Advisory Committee (RAC) of the American Association of State Highway and Transportation Officials (AASHTO). Through this participation (and prior to the official initiation of this project), significant work had already been completed to identify "benchmark" states for online project management systems. The 2013 RAC Summer Meeting in Baton Rouge featured a session focused on online project management and tracking systems. In preparation for that meeting, the RAC Summer Meeting Planning Committee solicited recommendations from around the country as to which states' systems should be featured in the session. That effort resulted in the selection of two states—Louisiana and Minnesota—to present information on their systems at the Summer Meeting. In addition, the Washington State DOT was asked to present information on a pooled-fund project for which they were the lead state. The PowerPoints used in those presentations were obtained by the project team and were reviewed in detail.

In addition to obtaining information on the Louisiana and Minnesota systems and the Washington-led pooled-fund effort, Kentucky sent out a request for information via the RAC listserv. The content of the request is reproduced here:

> The Kentucky Transportation Cabinet has undertaken a project to develop an online tracking system for all of the Cabinet's research projects. This management tool is intended to provide easily accessible, up-to-date information on project accomplishments and milestones, the current status of each project, and quick links to key project documents and deliverables. In addition to tracking the progress of active projects, the system will provide the capability to track the implementation of research results following project completion.
>
> We know that Minnesota and Louisiana have excellent project tracking systems in place, and we have obtained copies of their presentations from last summer's RAC Meeting. We would also like to know if there are other states that have similar systems in place. If you have a research project tracking system in place, and if you feel that it would be a good model for us to look at, please contact me and let me know who I should contact to get more information.
>
> We would appreciate responses by April 30, 2014. Thank you very much for any information or guidance that you are able to offer us as we develop this system.

This request for information generated responses from Georgia, North Carolina, Illinois, Texas, Virginia, and the Federal Highway Administration's Turner-Fairbank Highway Research Center. Several of the respondents provided information on their respective systems, and many of them indicated that they were very interested in Kentucky's project and would like to receive further information as the project proceeded.

Each state system identified as part of this task was reviewed by project staff to assess its capabilities, strengths, weaknesses, and any lessons learned that are applicable to Kentucky. Where necessary, the review included discussions with knowledgeable individuals who were users of the system being reviewed. The results of those reviews are summarized below.

Louisiana

The Louisiana Transportation Research Center (LTRC) has a system known as the "LTRC Project Management and Tracking System." The system was developed in-house, starting in 2008, using custom programming. It includes the following features and capabilities:

- The system is web-based, with access control via user ID and password. Varying levels of access are provided based on the needs of specific users.
- Provides a database of active and recently-completed projects, searchable by numerous factors, including project number, project type, funding source, project manager, principal investigator, start and end dates, etc.
- The system serves as a repository of project documents and files;
- Provides the capability to generate periodic progress reports for each project (LTRC generates biannual reports);
- Downloads financial information directly from the state financial system, generates financial reports, and provides access to the financial history of each project;
- Allows the creation of summary tables for the work program;
- Allows the tracking of implementation for completed projects and the generation of an implementation status report for each project;
- Allows the submittal of research problem statements to be considered for inclusion in the research program, the creation of committees to review these problem statements, the assignment of problem statements to committees, and the tracking of the ranking/prioritization process. (Note: the actual ranking process takes place in all-day meetings, not online.)
- The system has the capability for automatic generation of emails, triggered by specified events (such as the submittal of a research problem statement);
- Allows the tracking of publications through the submittal, review, and publication process.
- The capability is under development to document and track performance measures for the research program as a whole, for subsets of the program, or for specific projects.

The Louisiana system has extremely impressive and wide-ranging functionality. Because it is a custom system developed in-house, it is specifically tailored to the needs of LTRC and it provides great value to them. On the other hand, because it is a custom system, it requires significant levels of internal staff expertise, and it has been (and continues to be) fairly expensive to develop, debug, and refine. The system also requires significant investment in training users how to use it properly. The prospect of adapting the LTRC system for use in another state is rather daunting, but much can be learned from the LTRC system in terms of the types of capabilities that such a system can provide.

Minnesota

The Minnesota DOT (MnDOT) has an Automated Research Tracking System (ARTS). They have invested about $300,000 for the development and for five years of support of their system, which was originally developed to replace a financial spreadsheet. ARTS is a Microsoft Access database, accessible via the Internet for those with an assigned username and password. The system includes the following features:

- Built-in search capabilities;
- Customized reporting capabilities;
- Development and maintenance of email distribution lists;
- Automatic notification for overdue tasks or contracts that are due to expire;
- Project progress reports to view;
- Access to project files and deliverables, including final reports;
- Due date tracking of tasks and deliverables, current status (i.e., percent complete), and comments;
- Financial status and reports, including project budgets, expenditures, invoices, and payments. This includes reconciliation between cost accounting systems.
- Access to contract documents, partnership agreements, purchase orders, etc.;
- Tracking of the contract development process;
- The capability to enter research needs statements;

- Project evaluation forms; and
- A database of clients.

MnDOT has identified future enhancements for ARTS, including:

- Marketing capabilities, such as generating individual project pages on the public website and providing overall program information on the website;
- Workload summary reports by individual researchers, advisors, and managers;
- Gantt chart reporting;
- Automatically-generated quarterly progress reports;
- Enhanced tracking of schedule creep, budget revisions, and work plan amendments;
- Development of program-level assessment tools and implementation of program-level performance measures; and
- Monitoring and tracking of implementation efforts.

The MnDOT folks are quite pleased with their system and feel it provides substantial value. They note the challenge of keeping the information current and defining clear responsibilities for entering and updating the information. They also note that any such system needs to be updated and refined to keep it current as processes, procedures, and requirements change over time. Users must be trained to use the system properly, and this creates a challenge when new staff members come onboard.

Washington

The Washington State DOT (WSDOT) served as lead agency in a pooled-fund project numbered TPF-5(181). That project was established in 2008 and also involved Alaska, California, Indiana, Michigan, Nebraska, and New York. The objective was to explore modification of the Research Program Management Database (RPMD) developed by the California Department of Transportation (Caltrans) for use in other states. The project was also intended to develop enhancements to the RPMD, including a module for managing Transportation Pooled Fund projects and contributions.

The project had a total budget of $542,000 and was largely unsuccessful. The Caltrans system was based on FileMaker and was not web-based. It also turned out to be more complex (with more "layers") than what was needed by the other states. The report features designed to meet the needs of Caltrans did not match the needs of the other states. Modifications to the system and populating the databases for use in other states proved to be costly and labor-intensive, and most of the other states had limited internal resources for I.T. support. As a result, the project was eventually terminated with only one task fully realized.

North Carolina

The North Carolina DOT has a Microsoft Access database that is used to track the process, but that isn't publically visible, and it has limited functionality. The state is interested in a solution that is web-based and uses a relational database. They would like to find out about other states' experiences with off-the-shelf software that has been adapted for research management, as well as with solutions that have been developed in-house.

Illinois

The Illinois DOT has an internal database that tracks implementation for each project. They provided some screenshots, which were reviewed by the project team.

Texas

The Texas DOT uses SharePoint. They indicated that it interfaces reasonably well with Microsoft Project, and it "comes out of the box with a project management template."

FHWA's Turner-Fairbank Highway Research Center

The Turner-Fairbank Highway Research Center (TFHRC) uses the "Program Management Support System," or PMSS. This system, which is based on Microsoft SharePoint and InfoPath, serves primarily as a repository and a means of access for project documents and information. It provides the following capabilities:

- A web-based system, with three levels of user access controlled by username and password;
- The ability to access project documents via the document library;
- The ability to create custom views for accessing project documents. This includes the ability to sort documents, create filters, or group documents in a view;
- The ability to create new documents and make changes to existing documents;
- Check-in and check-out features to ensure that only one person can edit a document at a time;
- A "save as" feature that saves an existing document with a new name;
- The ability to save a document without submitting it, which is helpful for saving work in progress when a document is not yet ready to be submitted.
- The ability to view overall program information by funding source;
- Access to information on specific projects to meet project reporting requirements;
- The ability to store and access information on the key products and deliverables associated with each project;
- Alignment of projects to DOT and FHWA strategic initiatives;
- The ability to capture and access data on contracts, task orders, and modifications;
- The ability to capture and access financial and procurement data related to each project;
- A database of contacts can be generated, including sponsors, lead organizations, performing organizations, and collaborating organizations;
- A status summary can be provided for each project;
- The ability to export to Microsoft Excel;
- The ability to generate automated alerts; and
- Auto-population of selected fields based on prior selections.

The User Guide for PMSS was provided and was reviewed by the project team.

Virginia

Virginia has an old system based on a Microsoft Access database. They are beginning the process of revamping their system, with objectives similar to the Kentucky project.

3. Identifying Required and Desired System Capabilities (Task 2)

Using information gathered from the review of other states' systems, along with input from the project's Study Advisory Committee (SAC), a preliminary list of system capabilities (i.e., a wish list) was developed. This list was reviewed with the SAC to determine which of the listed capabilities were required and which were optional (i.e., desired but not essential). The resulting list, as approved by the SAC in February of 2015, is included below.

Table 1 Attributes/Capabilities of Kentucky's Research Project Tracking System

Attribute/Capability	Required	Desired
Serve as a repository and file-sharing location for all project-related files	X	
Searchable document library[1]	X	
Ability to view and edit documents, with version tracking and control	X	
Provide a database of active and recently-completed projects	X	
This database is searchable by various factors (e.g., project number, project type, funding source, PI, etc.)	X	
Display a list of all active research projects with links to each project's "home page"	X	
Include all KYTC research projects, not just those being performed by KTC	X	
Have a "home page" for each project with project summary, current status, and links to key documents	X	
Display current status of project tasks, milestones, and deliverables	X	
Track due dates for project tasks and deliverables		X
Record completion dates for key project milestones (this supports key performance measures)	X	
Provide Gantt charts (or equivalent) for projects		X
Display current financial status of project (spending versus budget, etc.)	X	
Display financial history of project	X	
Connect to financial systems (UK, KYTC, both?) to pull project financial data		X
Provide reconciliation of KYTC and UK financial systems		X
Track status (and maintain history) of invoices and payments		X
Provide capability for invoices to be submitted via this system		X
Providing backup documentation for invoices via this system		X
Provide a record of any revisions that are made to the project schedule and/or budget	X	
Generate reports on individual projects, groups of projects, or the entire program	X	
View the metadata to know what is there and what types of reports can be generated	X	
Include ability to create and save custom reports		X
Web-based; accessible from any site with a connection to the Internet	X	
Access controlled via user ID and password	X	
Different levels of access (and functionality) for different levels of users	X	
KYTC people able to access the system using their AD ID and password		X
KTC people able to access the system using their Link Blue ID and password		X
Provide security for files on the system that are NOT for public access	X	

Table 1 Attributes/Capabilities of Kentucky's Research Project Tracking System (continued)

Attribute/Capability	Required	Desired
Produce periodic reports to satisfy reporting requirements of KYTC and FHWA	X	
Track the status of implementation for each project for a specified period after project completion	X	
Include estimates of the value associated with the implementation (this supports key performance measures)	X	
Record key dates of implementation (this supports key performance measures)	X	
Generate summary reports of research implementation	X	
Allow submittal of research problem statements / project ideas		X
Provide tracking of submitted ideas from submittal to disposition (including recording key dates)		X
Provide ranking capability for project ideas		X
Automatic generation of annual SPR work program for submittal to FHWA		X
Allow creation of email distribution lists for SACs, PIs, R&I Executive Committee, etc.	X	
Automatic notification (e.g., generation of emails) triggered by specific, predefined events	X	
Allow defining and tracking of research performance measures		X
Provide online evaluation forms for customer feedback		X
Provide for the tracking of publications (e.g., final reports) through the submission, review, and publication process		
Marketing capabilities, such as generating individual project pages or providing program info on the public website		
Serve as a repository for contract documents (PONs, MOAs, etc.)		
Provide online discussion capabilities (chat, comments, etc.)		X
Manage Kentucky's Transportation Pooled Fund project involvement (commitments, payments, project status, etc.)[2]		X
Provide an online "master research calendar"		X
Provide a record of projects submitted to and accepted for "high-value research" designation by RAC, etc.	X	
Provide a record of projects selected for regional or national awards		X
Provide a record of papers submitted and accepted for publication in peer-reviewed publications (esp. TRB)	X	
Capture the number of students working on KYTC research		X
Capture the number of other entities working on KYTC research		X
Capture the amount of KYTC research funding being used as match for other projects		X

[1]Some level of searchability is required (e.g., keyword search), but more extensive search capabilities are optional.

[2]This may be handled by creating a project space for pooled-fund projects, so it may not need to be a separate capability.

4. Designing, Developing, Implementing, and Evaluating the Prototype System (Tasks 3 and 4)

4.1 System Design

Tasks 1 and 2 provided a foundation upon which the project team could design the Research Project Tracking System (RPTS). The RPTS was developed as a web-based system, so the preliminary design was sketched out in a series of webpage mockups. Selected mockups from March of 2015 are shown below:

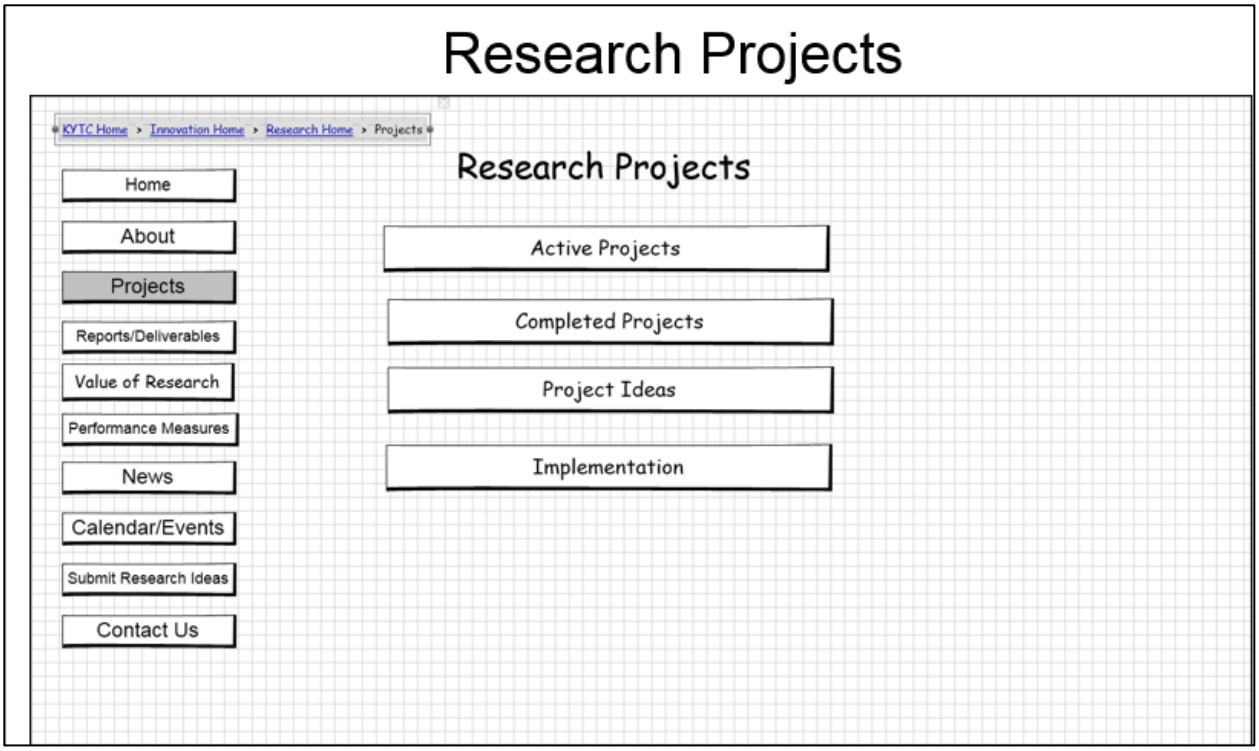


Figure 1 Mockup of RPTS Projects Page

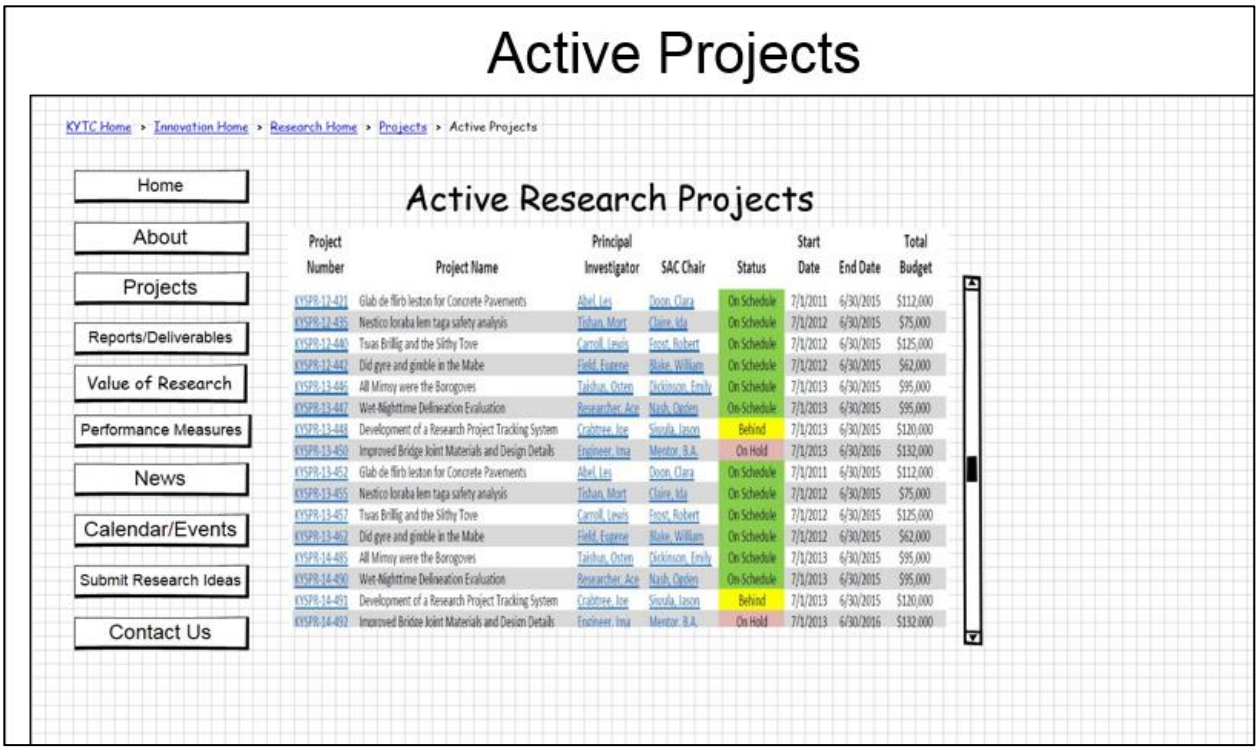


Figure 2 Mockup of Active Projects Page

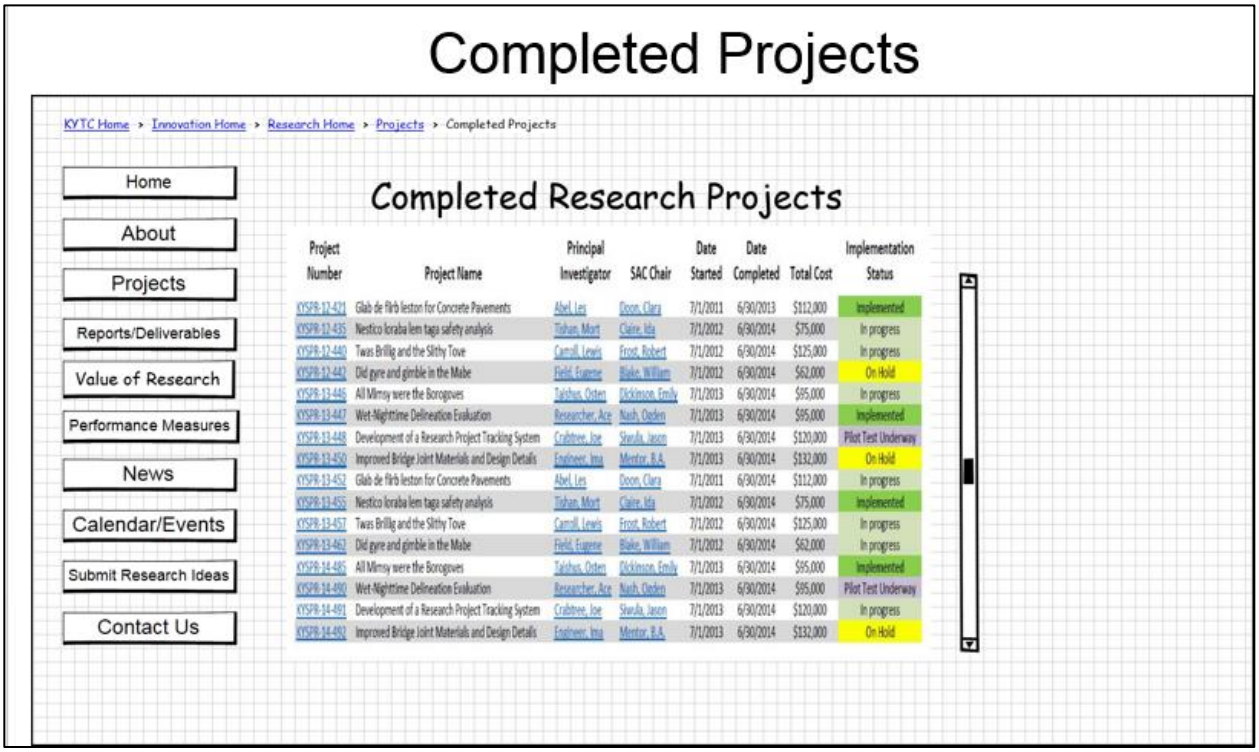


Figure 3 Mockup of Completed Projects Page

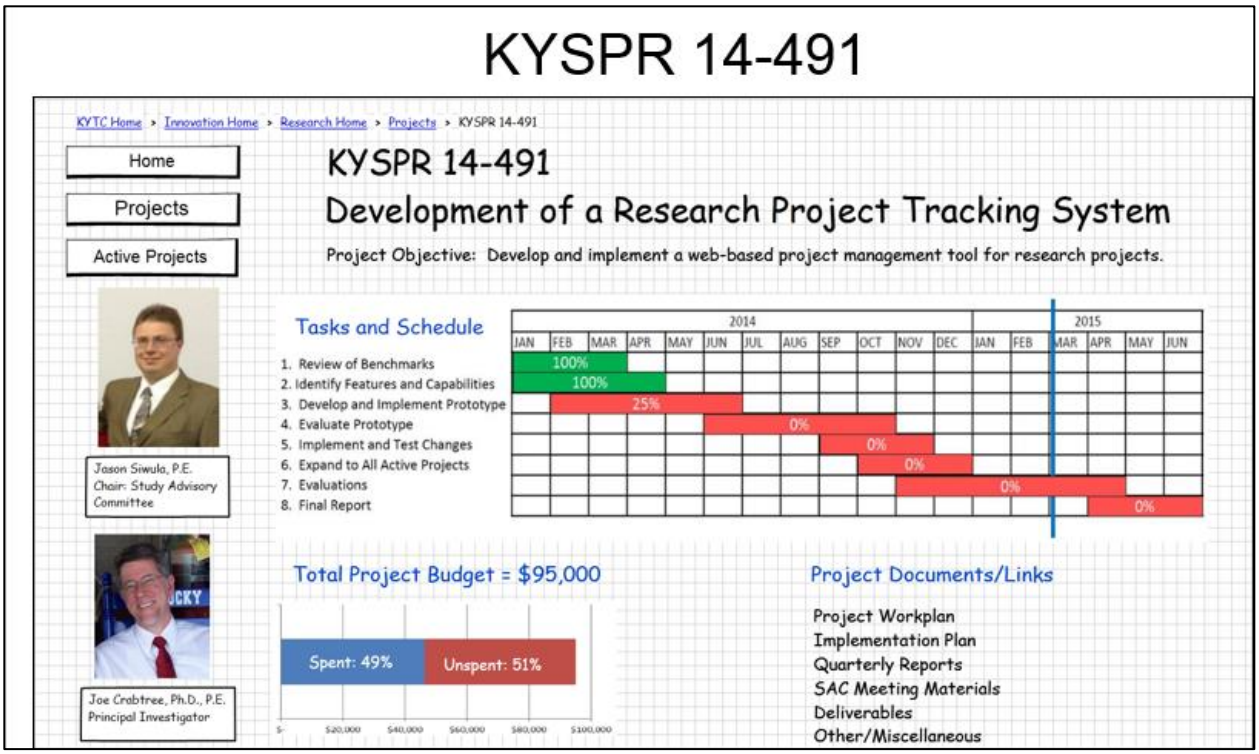


Figure 4 Mockup of a Typical Project's Homepage

Included in these mockups were preliminary table structures for the listing of active and completed projects (see Figures 2 and 3). Of course, the database would need to contain much more data for each project than what would be shown in the table. A preliminary design was prepared for the project database, which listed all of the proposed fields, along with information on the purpose and recommended format of each field. That preliminary design from March of 2015 is presented in Appendix A of this report.

4.2 System Development

In May of 2015, following an extensive search, a new web developer/programmer was hired by the Kentucky Transportation Center to work on the RPTS. The prototype RPTS was developed in May through September of 2015, using the webpage mockups and preliminary database design that had been developed earlier that year.

The RPTS was developed as a Web-based program running on a dedicated server. It was built using the Microsoft Visual Studio 2015, an Integrated Development Environment (IDE) for writing, running, and testing code. The language used is C#, the state-of-the-art C language, which is widely used and relatively easy to learn. The Web platform used is Microsoft MVC (Model View Control), part of ASP.net. The RPTS project-specific data is stored on a dedicated computer running Microsoft SQL Server on the local network; access is password protected.

The MVC approach was selected because of the highly-integrated suite of features that allows direct interaction with an SQL Database Table called Entity Framework, (EF) which is an Object/Relational Mapping (O/RM) framework. It is an enhancement to ADO.NET that gives developers an automated mechanism for accessing & storing the data in the database. EF is built into the MVC projects in Visual Studio as an option, and helps automate connecting to a database table. The RPTS developers utilized Entity Framework, thereby taking advantage of the newer LINQ (Language Integrated Query) syntax that replaces the need for traditional SQL statements. LINQ is a set of features that extends powerful query capabilities

to the language syntax of C#. LINQ introduces standard, easily-learned patterns for querying and updating data, and allows objects stored in a Database Table to be directly accessed from code. The interaction of written code and the stored data/objects in the SQL database are commonly referred to as Back-End code.

The RPTS utilizes the Twitter Bootstrap add-in for the Website's Front-End, which is the HTML and the part of the code with which the users interact. Bootstrap is an open-source Javascript framework developed by the team at Twitter. It is a combination of HTML, CSS, and Javascript code designed to help build user interface components. Bootstrap was also designed to support both HTML5 and CSS3. Bootstrap allows a mechanism to interface with the HTML and code to generate the actual web page. Features utilized in the RPTS development included the re-sizing of a page and fitting objects automatically, a reliable mechanism to check the value of text input boxes, and the ability to add a range to those input values.

In Visual Studio there is a feature called NuGet to manage a project's specific add-ins and optional features. NuGet allows the developer to locate and easily install add-ins such as a DateTime Picker or a Charting Software package. When the project needs to be set up on a new development platform, the user simply opens the Solution file (*.sln) with Visual Studio, clicks on Build, and NuGet will find and install all of the dependencies automatically and report the status. This makes the RPTS easily portable for setup and continued development on another computer.

The RPTS generates reports in Microsoft Word and Excel directly from the code. Both Word and Excel are complex objects that utilize the XML (Extensible Markup Language) format to structure their content. Microsoft released a software development toolkit called OpenXML to allow users to set up mechanisms to search or modify Office documents. The RPTS uses OpenXML to construct and format custom Word documents containing report data and a bar chart. Currently the RPTS does this by using just over 12,000 lines of code. The RPTS uses an add-on package called ClosedXML to generate custom Excel documents.

The RPTS stores and presents archival data by utilizing links to Dropbox. For each project a website is automatically generated from the code that displays key project information, including a photo and email address for the project's principal investigator and the Chair of the study advisory committee. The information on key project documents is editable and is displayed as links. These links connect to the Kentucky Transportation Center's stored Dropbox files where thousands of files are managed. Linking to Dropbox allows the RPTS to satisfy the requirement of providing access to key project documents while keeping those documents in the cloud and password protected.

Links to some of the key tools used in the development of the RPTS are provided below.

Tool	**Link**
Microsoft SQL Server	https://msdn.microsoft.com/enus/library/mt590198(v=sql.1).aspx
Microsoft Visual Studio	https://msdn.microsoft.com/enus/library/dd831853.aspx?f=255&MSPPError=-2147217396
Microsoft MVC	https://www.asp.net/mvc
Microsoft C# Language	https://msdn.microsoft.com/enus/library/1zx9t92.aspx
Microsoft Entity Framework	https://msdn.microsoft.com/enus/library/bb399567(v=vs.110).aspx
Microsoft LINQ for C#	https://msdn.microsoft.com/enus/library/mt693024.aspx

Bootstrap	http://getbootstrap.com/css/
NuGet for Visual Studio	https://www.nuget.org/
XML	https://msdn.microsoft.com/enus/library/aa286548.aspx?f=255&MSPPError=-2147217396
OpenXML (ECMA)	http://www.ecmainternational.org/news/TC45_current_work/OpenXML%20White%20Paper.pdf
OpenXML (Office)	https://msdn.microsoft.com/enus/library/office/bb448854.aspx
ClosedXML	https://github.com/closedxml/closedxml
Dropbox	https://www.dropbox.com/tour/0
JQuery and JavaScript Add-Ins	
DHTMLX Gantt and BarChart	http://dhtmlx.com/
AngularJS (Google)	https://angularjs.org/
JQuery DateTime Picker	http://xdsoft.net/jqplugins/datetimepicker/
BootStrap Date Picker	https://github.com/uxsolutions/bootstrap-datepicker
MomentJS	http://momentjs.com/

4.3 Preliminary Evaluation of System

The prototype system was populated with data for all active State Planning and Research (SPR) projects and was used to produce the quarterly progress reports (QPRs) for all SPR projects for the quarters ending 6/30/15, 9/30/15, and 12/31/15. Evaluation of the prototype system took place from July 2015 through January 2016. Over the course of that evaluation, a list was developed of changes that were either needed or desired. That list is provided here:

Basic Functionality/Utility/Appearance

- Ensure system works with IE, Firefox, Chrome
- Ensure system works on tablets
- Simplify project list to include only essential columns
- Provide rudimentary search capability for list mode
- Provide enhanced navigation among screens
- Provide a home page for the RPTS
- Improve visual appeal of RPTS home page
- Develop a table of PIs and SAC Chairs
- Add the capability to create the project workplan directly from the RPTS
- Add capability to pull financial data from FRS or from spreadsheet

Add ability to create canned and/or customized reports

Login and Security

Require system login using LinkBlue credentials
Provide alternate login for KYTC folks
Provide different levels of access for different users

Edit Screen

Provide a floating save button in edit mode
Remove the "delete" option to make deletion and administrator-only action
Provide ability to save without exiting edit mode
Provide warning when exiting with unsaved changes
Provide quick shortcuts to navigate directly to different sections of the edit screen
Provide standard entry of dates for all date fields
Project entity — make this a dropdown/selection
Add ability to indicate which account number is active
Add ability to indicate which funding strip is active
Add ability to indicate whether the project is used to provide matching funds
Add "total budgeted" and "total expended" sums to page
Remove need for PI to indicate status of task
Add capability to assign % effort to each task
Display a checksum for % effort (for PI to ensure it totals to 100%)
Remove separate deliverables section and incorporate into milestones
Provide capability to enter links to key project documents
Provide capability to enter links to photos, etc.
Add a field for capturing the Date/Time stamp when the record was last modified

Quarterly Progress Reports, etc.

Add the "billed this quarter" information to the QPR
Modify the filename structure to include the quarter ending date in the filename
Include all necessary QPR Data in Database
Store historical QPR data
Determine status of task automatically from % complete
Determine automatically if any task is behind schedule
Determine automatically if any milestone is overdue
Limit display of task information to the number of tasks actually used
Revise display of financial information to include future-year programmed funds
Develop capability to produce monthly progress reports from RPTS
Add bar charts to QPRs for % time elapsed, % work completed, % funding spent

Project Home Page / Dashboard

Develop a project home page / dashboard
Provide links to key project documents on project home page

Ensure that everything required to populate project home page is in database

Add bar charts to dashboard for % time elapsed, % work completed, % funding spent

Expand the home page / dashboard to every project

The system evaluation, identification of needed changes, and the implementation of those changes occurred continuously throughout the seven-month evaluation period. The process was iterative, with improvements being implemented and evaluated on an ongoing basis.

5. System Enhancement, Testing, and Final Evaluation (Tasks 5 and 6)

5.1 Implementing and Testing Changes

The implementation of needed/desired enhancements (as identified by the evaluation of the prototype system) occurred throughout the evaluation period (July 2015 through January 2016) and for an additional two months. The following tables show the resulting status (as of the end of March 2016) of each of the needed/desired changes that had been previously identified.

Table 2 Basic Functionality/Utility/Appearance

Change	Status	Comments
Ensure system works with IE, Firefox, Chrome	Complete	
Ensure system works on tablets	Complete	
Simplify main project list to include only essential columns	Complete	
Provide rudimentary search, sort, and filter capabilities for project list mode	Partially Complete	Only by PI name and project no.
Provide enhanced navigation among screens	Complete	
Provide a home page for the RPTS	Complete	
Improve visual appeal of the RPTS home page	Complete	
Develop a table of PIs and SAC Chairs	Complete	
Add capability to create a project work plan directly from the RPTS	Deferred	Bumped by more urgent items
Add capability to pull financial data from UK's accounting system or from spreadsheet	Deferred	Ditto
Add capability to create canned or customized reports	Deferred	Ditto

Table 3 Login and Security

Change	Status	Comments
Require system login to edit database	Complete	
Allow login using LinkBlue credentials	Complete	
Provide alternate login for Transportation Cabinet folks	Complete	
Provide different levels of access/permissions for different users	Complete	

Table 4 Database Elements and Edit Screen

Change	Status	Comments
Provide a floating save button in edit mode	Complete	
Remove the "delete" button from the edit screen to make deletion an administrator-only option	Complete	
Provide ability to save project edits without exiting edit mode	Complete	
Provide a warning when exiting with unsaved changes	Complete	
Provide quick shortcuts to navigate directly to different sections of the edit screen.	Complete	
Provide a standard format for the entry of dates for all date fields	Complete	
Improve the clarity of labeling for selected fields in the "Milestones and Deliverables" section	Complete	
Have dollars and percentages display as dollars and percentages (not just numbers) on the edit screen	Complete	
"Project Entity" – make this a dropdown list	Complete	
Add a field for the UK account number and allow for more than one	Complete	
Allow for more than one funding strip entry	Complete	

Add ability to indicate which account number is active	Complete	
Add ability to indicate which funding strip is active	Complete	
Add an indicator for whether the project is used to provide matching funds	Complete	
Add "total budgeted" and "total expended" sums to the edit screen	Complete	
Remove the need for PI to indicate the status of each task. Have the system deduce status from % complete.	Complete	
Add capability to assign a "percent of total effort" to each task	Complete	
Display a checksum for percent of total effort	Complete	
Remove the separate section for deliverables. Incorporate this into the milestones section.	Complete	
Add the ability to enter links to key project documents	Complete	
Add the ability to enter links to photographs, etc.	Complete	
Capture and display the date and time when the record was last modified.	Complete	

Table 5 Quarterly Progress Reports, etc.

Change	Status	Comments
Add the "billed this quarter" information to the QPR	Complete	
Modify the filename structure to include the quarter ending date in the filename	Complete	
Ensure that all data necessary to generate the QPR is in the database, so that no data entry is required at the time of generating the QPR.	Complete	
Store historical QPR data	Complete	
Determine the status of tasks automatically from % complete	Complete	
Determine automatically if any task is behind schedule	Complete	
Determine automatically if any milestone is overdue	Complete	
Limit display of task information to the number of tasks actually used	Complete	
Revise the display of financial information to include programmed funds for future years	Complete	
Develop the capability to produce monthly progress reports from the RPTS	Partially complete	Began work on this; not completed
Add bar charts to the QPR to indicate % time elapsed, % work completed, and % funding spent.	Complete	

Table 6 Project Home Page / Dashboard

Change	Status	Comments
Develop, implement, and test a project home page / dashboard	Complete	
Provide links to key project documents on the project homepage	Complete	
Ensure that everything required to populate the project homepage is in the RPTS database	Complete	
Add bar charts to the project dashboard to indicate % time elapsed, % work accomplished, and % funding spent.	Complete	
Expand the homepage / dashboard to every project in the RPTS	Complete	

As indicated in these tables, the vast majority of the needed/desired changes identified during the preliminary evaluation were successfully implemented during Task 5. Also, several additional enhancements were identified and implemented during Task 5. These included:

- Provided additional checking for invalid or out-of-range data (with immediate notification) for various fields throughout the database.
- Added a field in the database for "program area" to indicate which research program area at KTC has primary responsibility for managing the project.
- Enhanced the logic in the system to automatically determine if a task is behind schedule or if the overall project is behind schedule.
- For the project list mode, added the capability to filter the list by project status (pending, active, or completed).
- Added a "reports" page. This will be the "launching place" for generating various canned and/or custom reports.
- Enhanced the table of Principal Investigators and Study Advisory Committee Chairs to be a table of system users, with appropriate fields (including role and permission level) for each user.
- Defined and implemented the different levels of access and permissions for each user.
- Restricted the LinkBlue login so that only authorized users (in the table of users) can access the system. (Previously, anyone with a valid LinkBlue ID and password could access the system.)

5.2 Final System Evaluation

In truth, the Research Project Tracking System was being continually evaluated and enhanced throughout the development and evaluation process (Tasks 3 through 6). The "official" final evaluation of the system, as called for in Task 6, occurred from April through July of 2016. This allowed the system to produce two more sets of quarterly progress reports (end of March and end of June) as part of the evaluation. In addition to those few items that were identified in the preliminary evaluation but not completed, this second evaluation identified several recommendations for future enhancements for the system. The following table includes all items on the resulting punch list for the RPTS.

Table 7 Remaining Issues or Desired Enhancements for the Research Project Tracking System

Description of Issue or Enhancement	Comments
Add capability to create a project work plan directly from the RPTS	This was not an urgent item in terms of basic RPTS functionality, but it has been identified as an extremely valuable enhancement. It should be a high priority moving forward.
Add capability to pull financial data from UK's accounting system or from spreadsheet	Work has begun on pulling in data from a spreadsheet, which will eliminate manual data entry.
Add capability to generate canned or customized reports.	System generates quarterly progress reports. Work is well underway to automatically generate a QPR executive summary spreadsheet. Additional report-generating capabilities need to be added.
Develop the capability to produce monthly progress reports	For some of our projects, the project sponsors require monthly reporting. We want to be able to generate these reports directly from the RPTS.
Enhance bar charts to be able to show more than 100% time elapsed for funding spent	This has been successfully enhanced on the project websites, but issues remain with the display on the QPRs. This is an urgent priority.
Add the capability to automatically generate the spreadsheet for the executive summary of the QPRs	As noted above, this work is well underway.

Enhance the ability to search and filter the project data	The current system allows searching and filtering by PI name, project number, and project status. It needs to allow searching and filtering by other data elements.
Enhance the ability to track implementation of research projects	This ability is currently there as a placeholder. It needs to be used, assessed, and enhanced as needed.
Add automatic notification capability for pre-defined events	This has not yet been addressed in the design or development.

At this point, in terms of SPR Project 15-491, the development of the Research Project Tracking System is complete. It is anticipated that work will continue on the desired enhancements to the extent allowed by available funding and resources.

Appendix A

Initial Design of Database for Research Project Tracking System

From March 2015

Research Project Tracking System Draft 3/3/2015
Proposed Database Fields

Project Number		Need to ensure that we have consistent formatting here. This could be challenging (or require human QC)
Project Name	This is a text field. This will be the official project name. All other documents (work plan, etc.) should match up with this.	
Project Type		This could be SPR, KHIT, FRT, RSS, RSS, etc. It would be good to have a drop-down list.
Funding Source / Funding Strip		I'm not sure what goes here. Should this be the funding strip or a more general funding source (perhaps with a drop-down list)?
Project Type		This could be SPR, KHIT, FRT, RSS, RSS, etc. Can we have a drop-down list? Is this redundant with funding source?
Entity conducting project		This acknowledges that we may have projects in the system where the work is being done by someone other than KTC.
Date Approved		I'm envisioning that this is the date that the project is approved by KYTC (i.e., the date the "blue sheet" is signed.
Start Date		
Scheduled End Date		
Actual End Date		This could be unnecessary. Can we get this from the actual completion dates in the task breakdown below?
Current Status		This would be a drop-down list (pending, active, completed, etc.). Is this field necessary, or can this be inferred from other fields?

Project Budget/Spending Breakdown

Fiscal Yr	Budgeted Amount	Actual Expended
Total Project Budget/Spending		

Do we need to provide a mechanism for projects that may not be set up on a fiscal year basis? Do we need to keep a record of spending on a monthly or quarterly basis? (This will exist in our financial system; do we also need to keep this information here?)

Name of SAC Chair		We need to define the format to be used (e.g., last name first, first name first, etc.)
Email Address		
Name of Principal Investigator		Ditto
Email Address		

Project Tasks Breakdown

(Note: We could add a "status" column, but I would like the system to determine the status based on the scheduled dates and the % complete.)

Task No.	Task Name	Sched Start Date	Sched Complete Date	% Complete	Actual Complete Date	Comments

Project Milestones

(Note: I can see some potential redundancy with tracking tasks and milestones, since some milestones will align with the completion of tasks.)

Number	Description	Scheduled Date	Actual Date	Comments

Project Deliverables

(Note: I can see some potential redundancy with tracking tasks, milestones, and deliverables.)

Deliverable Number	Description	Scheduled Date	Actual Date	Report Number (If Applicable)	Comments

Revisions to Work Plan

Revision Date	Description	Funds Added? Y/N	Time Extension? Y/N

Overall Project Comments/Updates

(Note: This provides a place for those involved in the project to enter commentary and details that might not fit anywhere else. This becomes part of the historical record.)

Date	Comment/Update

Implementation Assessment Approval [ ] Approval date for the initial implementation Assessment

Implemantation Plan Approval [ ] Approval date for Implementation Plan

Implementation Status [ ] This will be a drop-down box. We will define the different status options.

Implementation Record

Date of Implement.	Description of Impl.	Cost of Implement	Value of Implement

Appendix B

Screen Captures from Research Project Tracking System

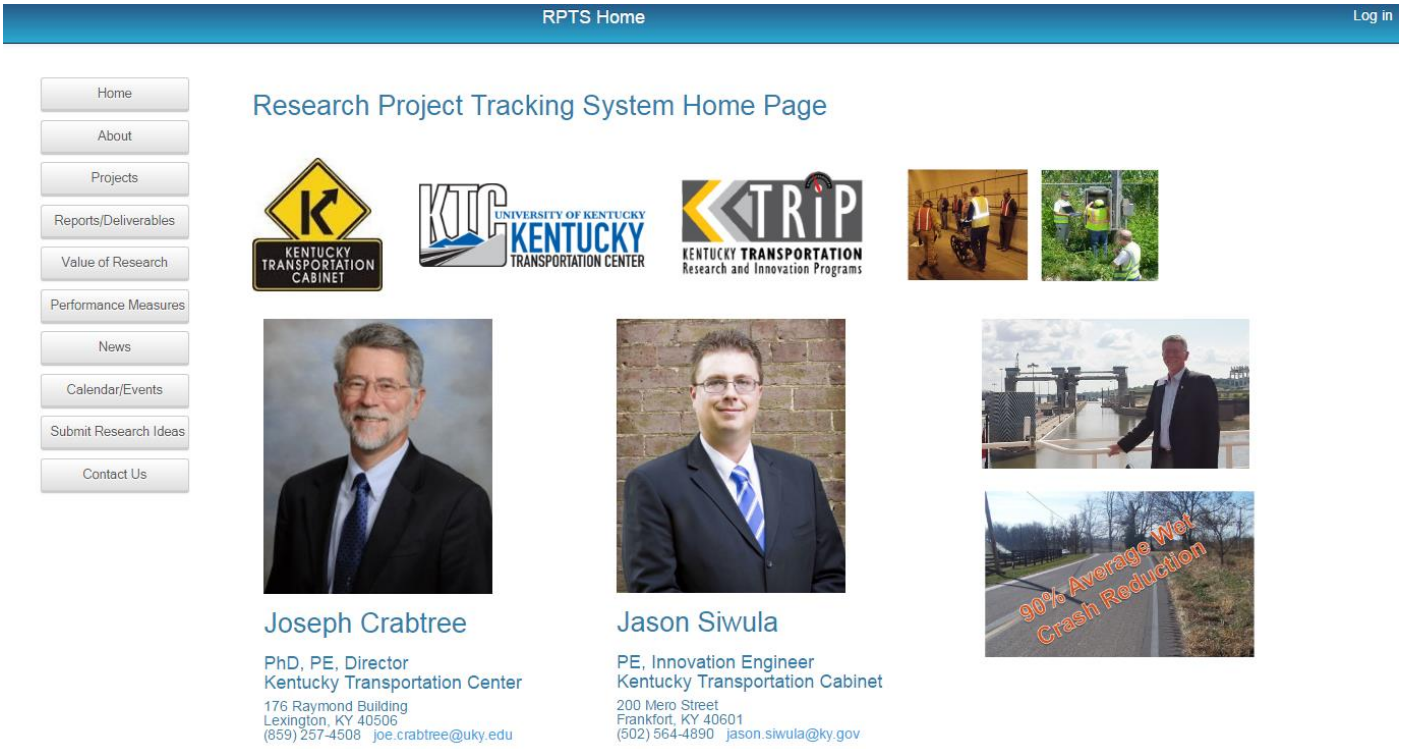


Figure B-1 RPTS Home Page

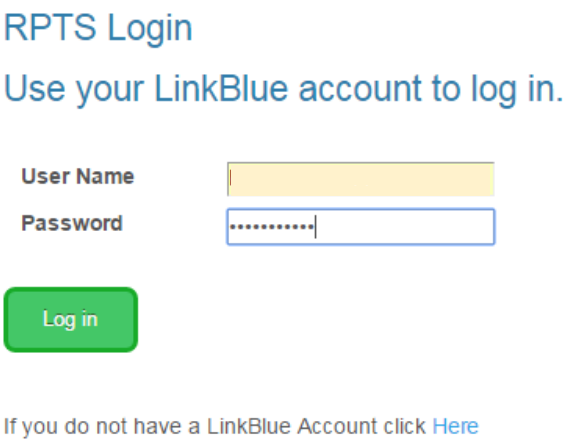


Figure B-2 RPTS Login Screen with LinkBlue

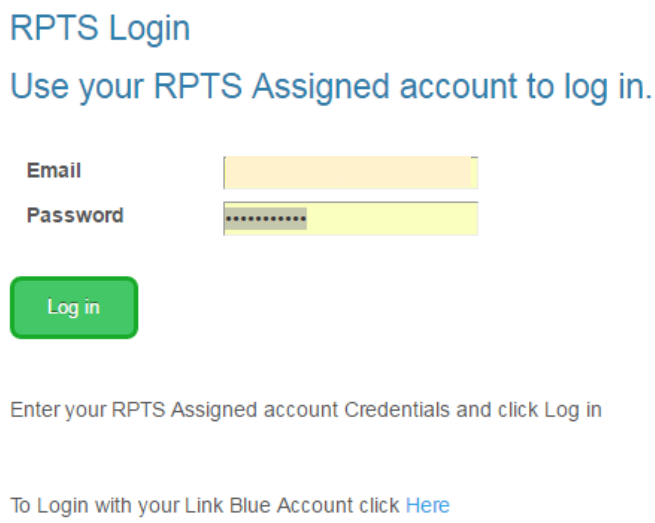


Figure B-3 RPTS Login Screen with custom credentials

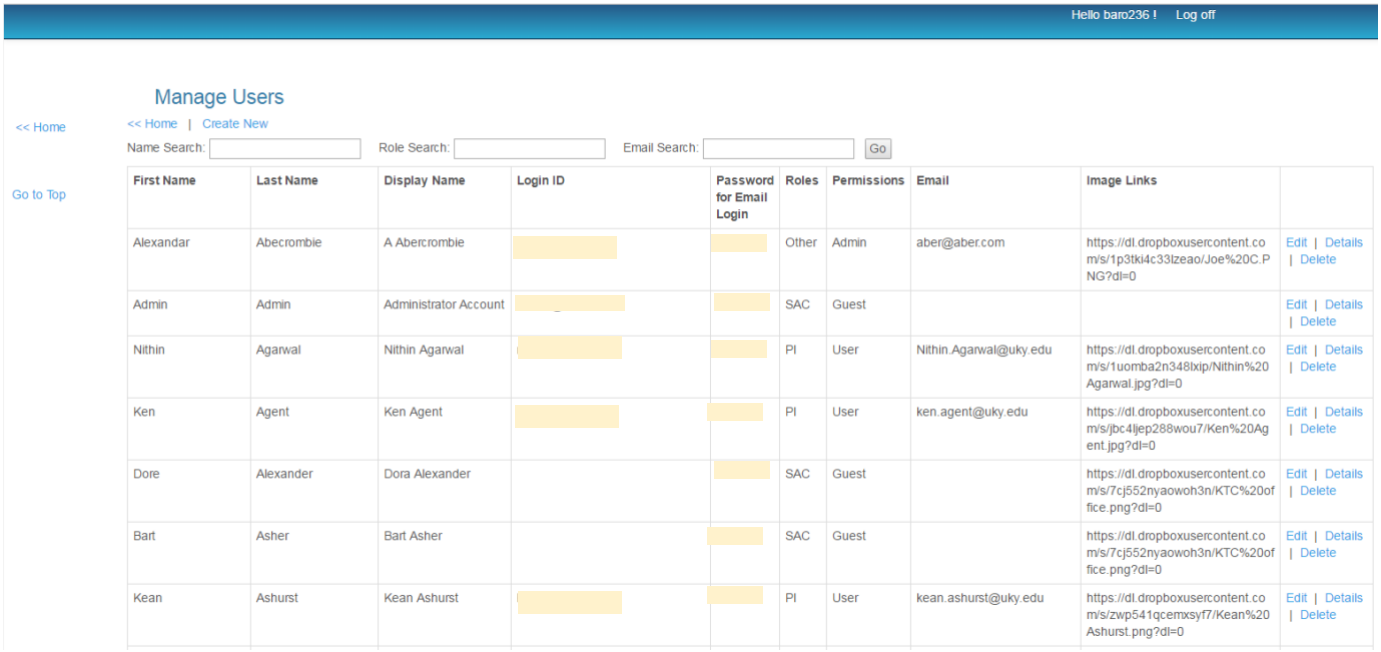


Figure B-4 Manage Users Page. This page allows administrators to access and edit user information.

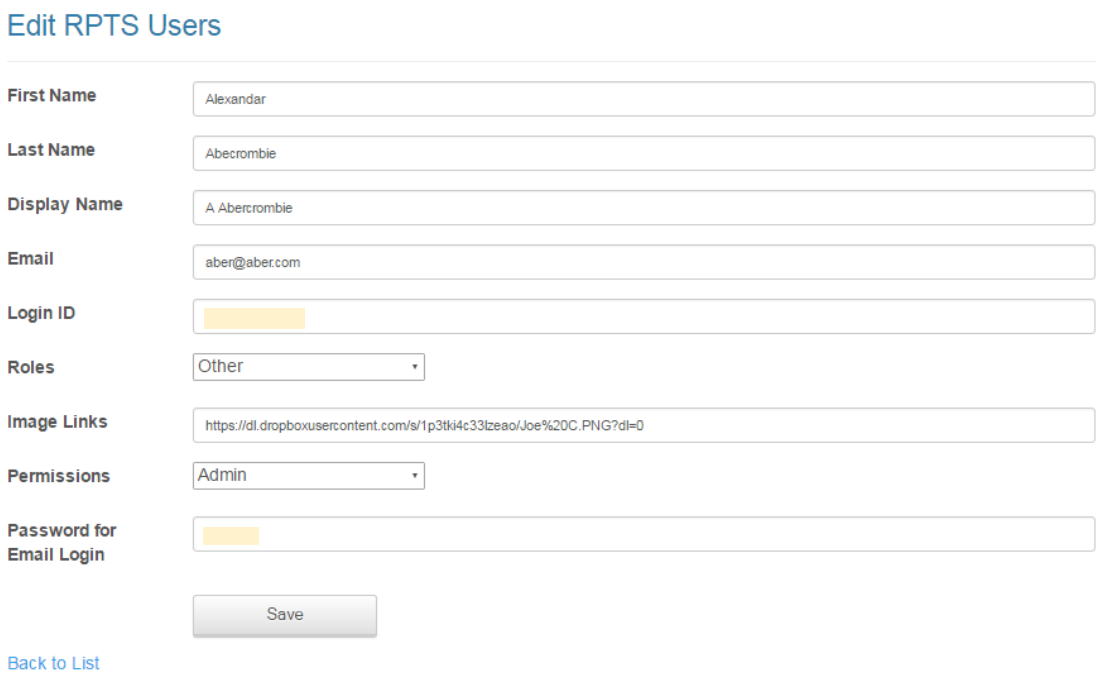


Figure B-5 Edit an RPTS User Page. This page has the settings for the contact information and a link to the user's photo.

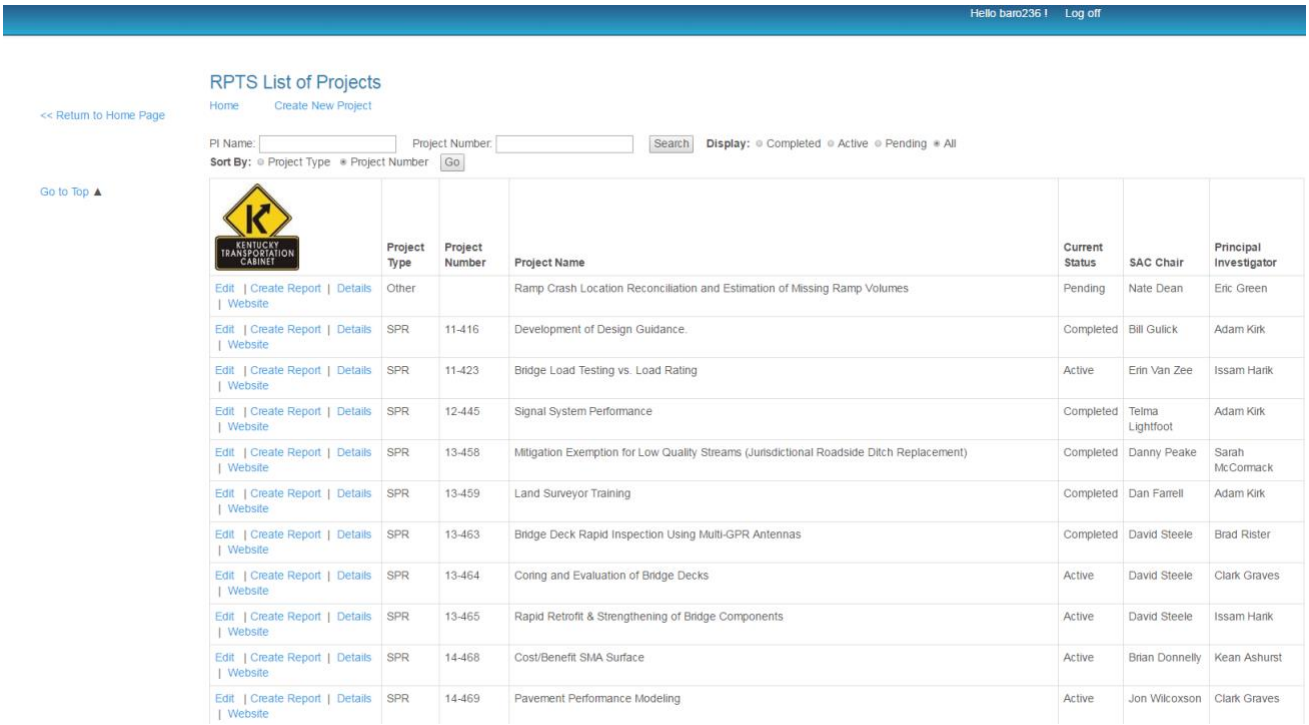


Figure B-6 RPTS List of Projects

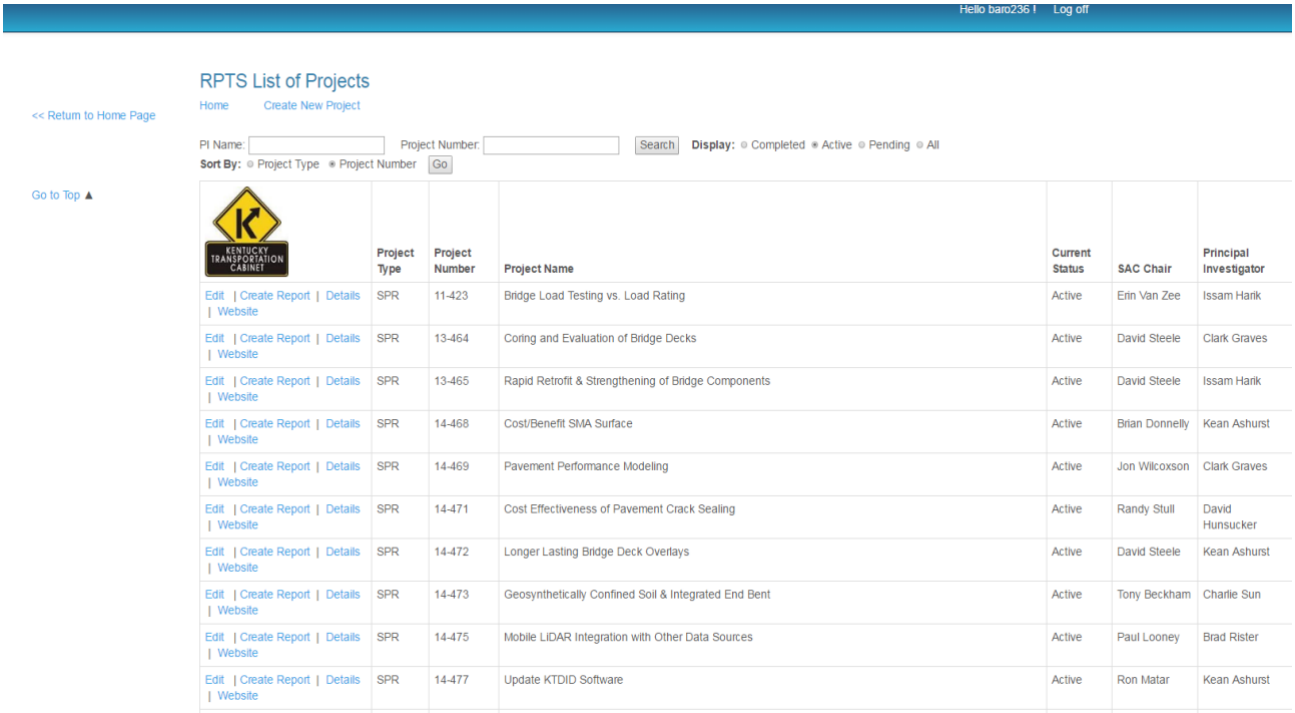


Figure B-7 Projects can be filtered to show Completed, Active, Pending, or All

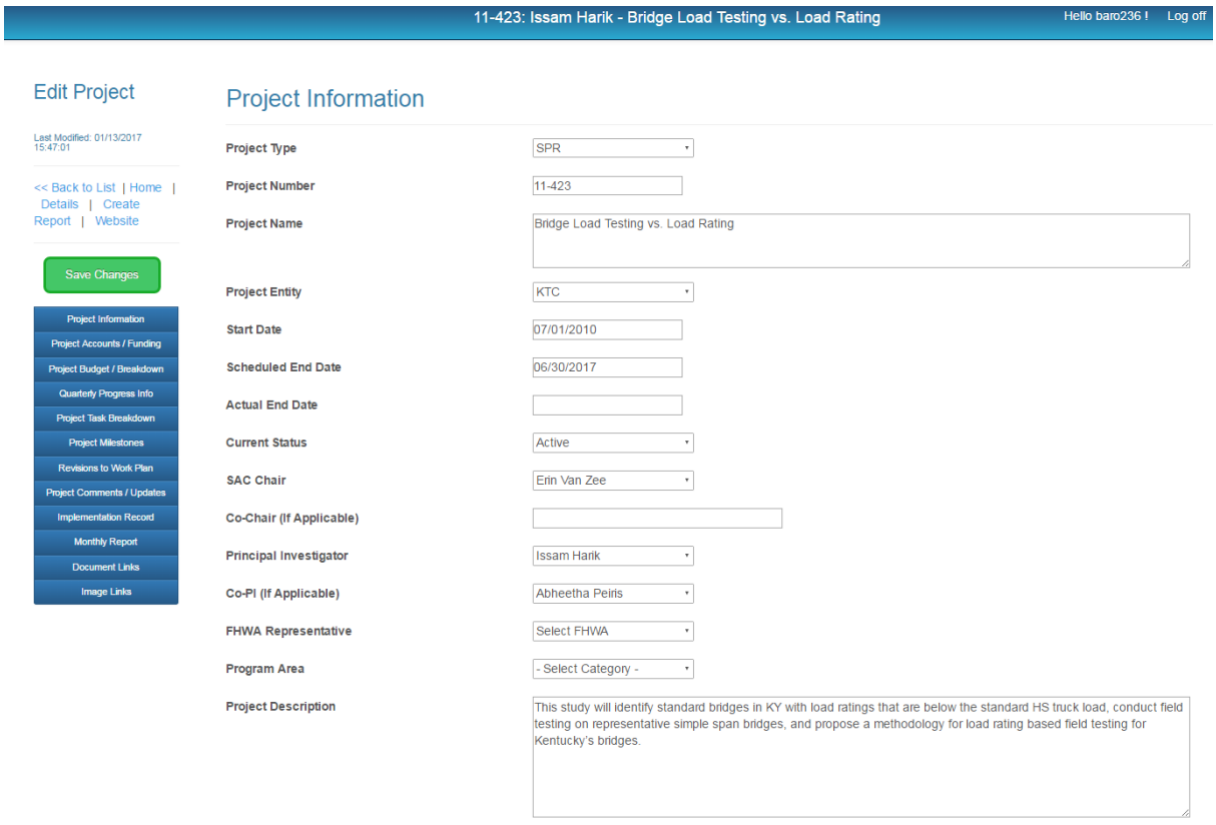


Figure B-8 The "Edit Project" Screen

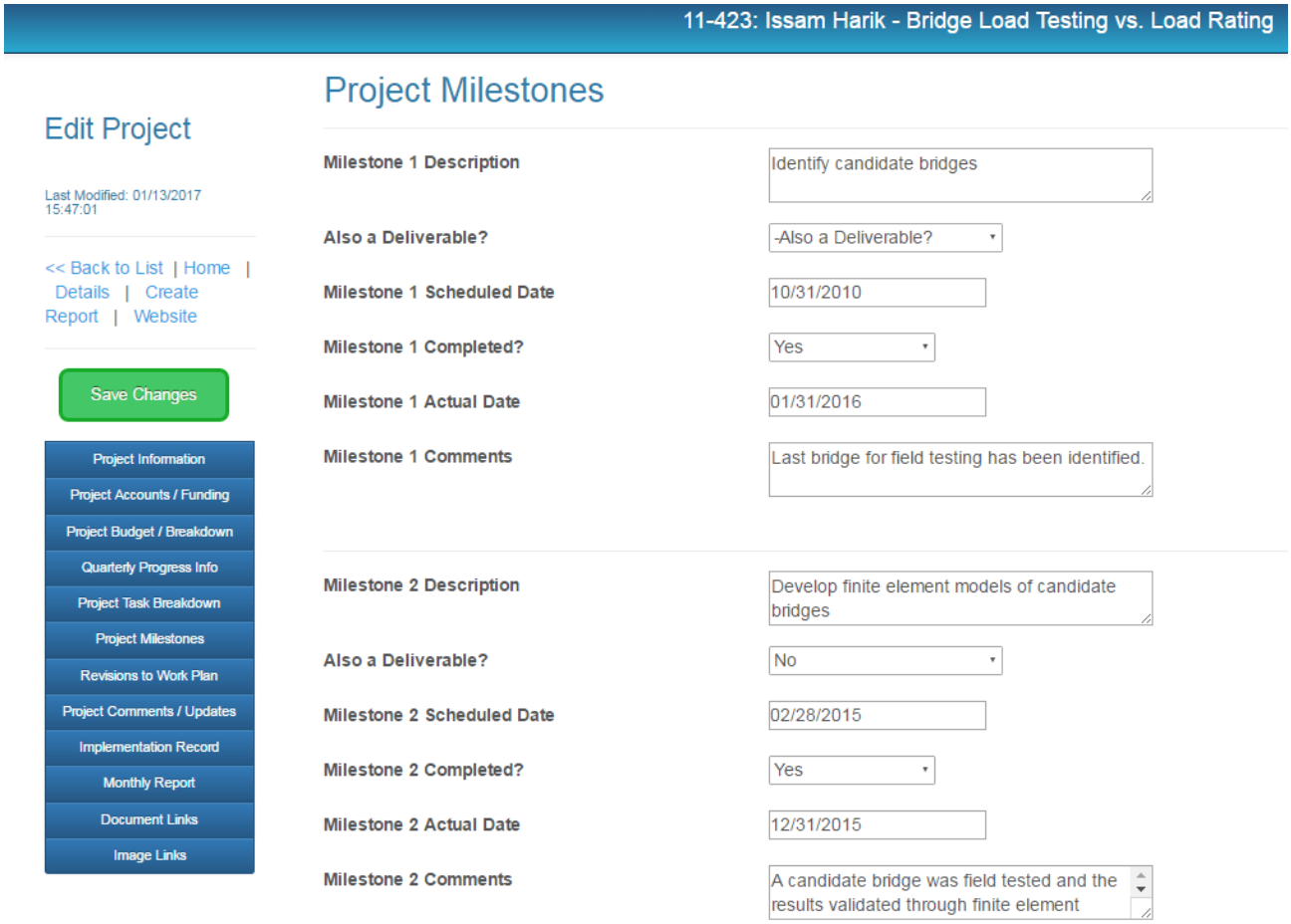


Figure B-9 The user can navigate through the sections of the "Edit Project" screen by scrolling up and down or by using the "quick navigation" buttons on the left.

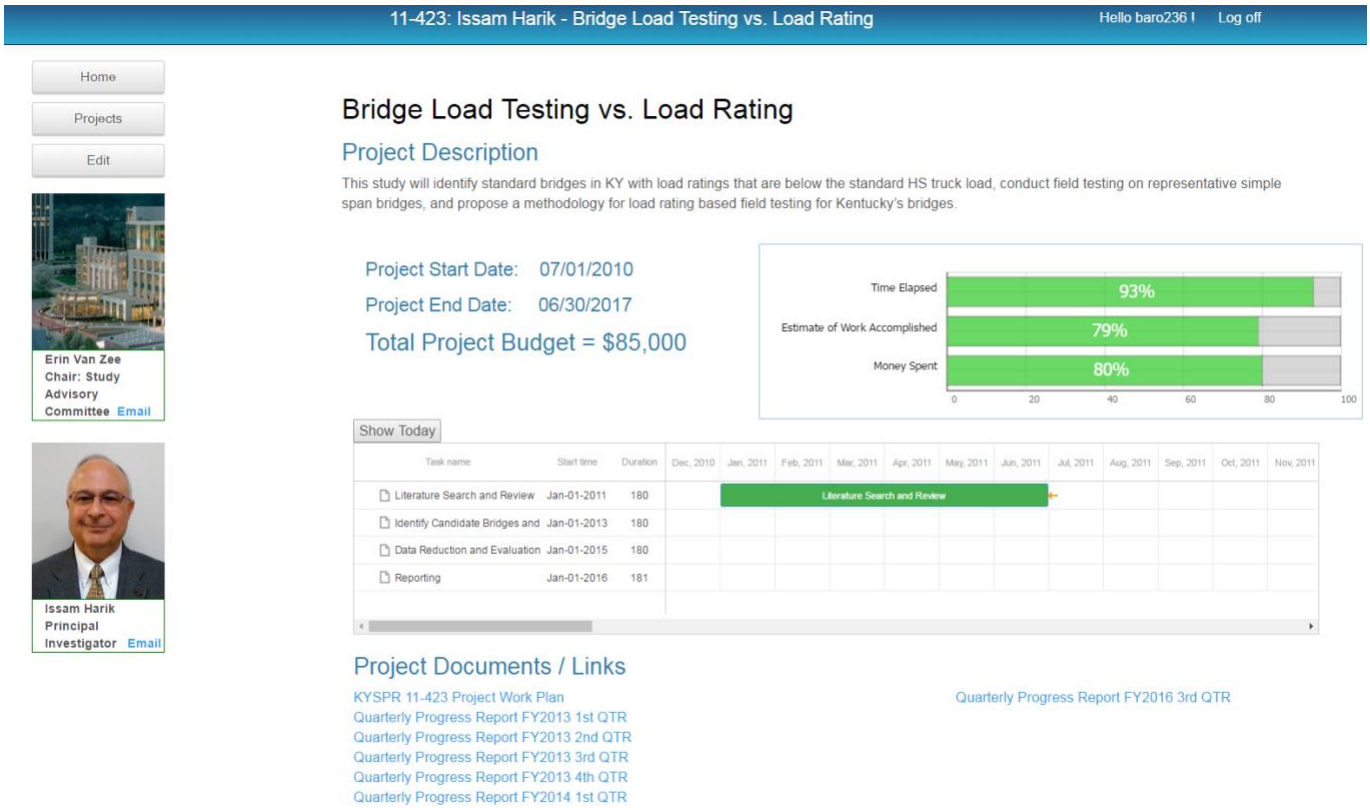


Figure B-10 Each Project has its own automatically-generated web page showing basic project information along with links to key project documents.

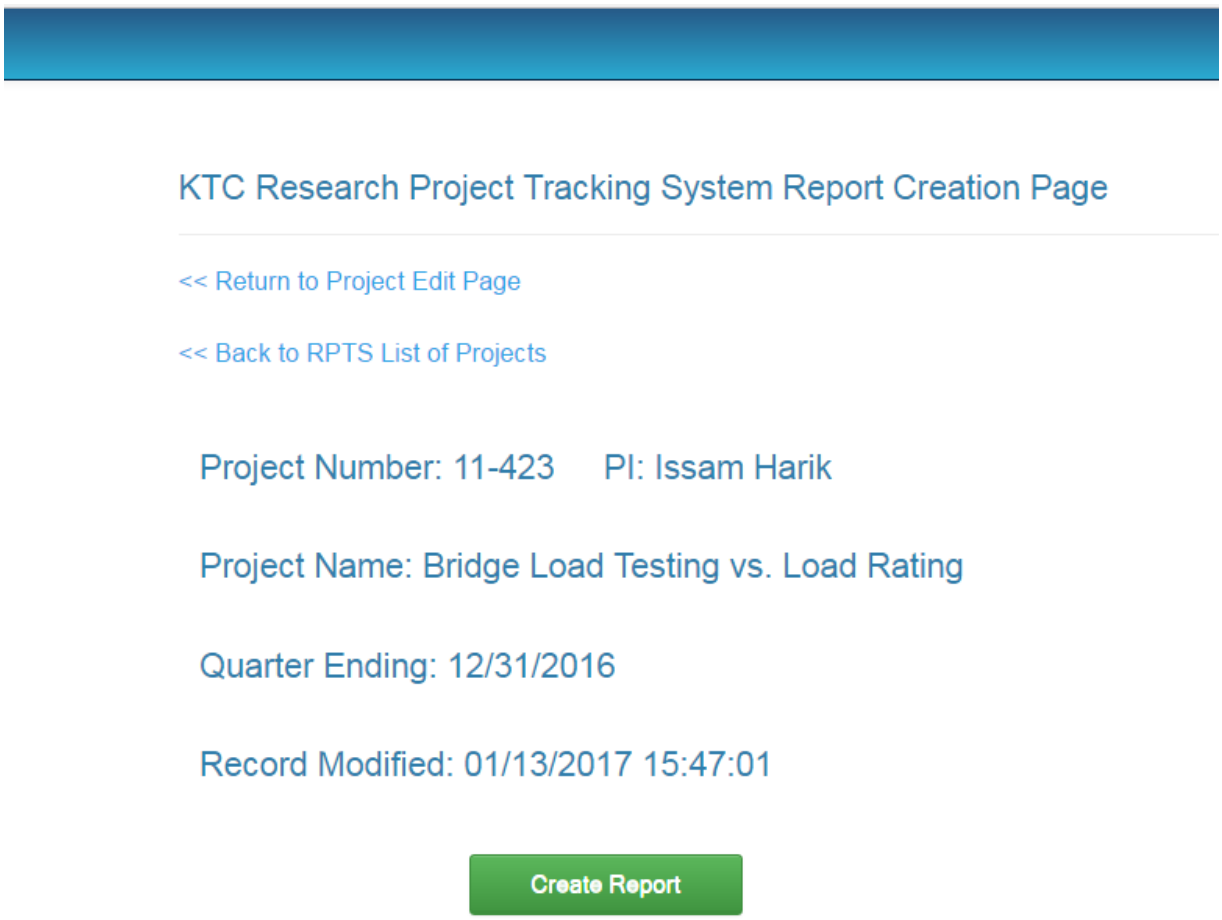


Figure B-11 Clicking on "Create Report" on either the List of Projects screen or the Edit Project screen will bring up this confirmation screen. From this screen, clicking on the green "Create Report" button will create a Microsoft Word document. That document is a quarterly progress report for the project.

KYSPR 11-423 Bridge Load Testing vs. Load Rating

Quarter Ending: 12/31/2016 **SAC Chair:** Erin Van Zee **PI:** Issam Harik **Begin Date:** 07/01/2010

Scheduled End Date: 06/30/2017

Status of Project Tasks

Task	% Complete	Planned Date	Actual Date
Task 1: Literature Search and Review	100 %	6/30/2011	3/30/2015
Task 2: Identify Candidate Bridges and Conduct Field Testing	100 %	6/30/2013	8/31/2016
Task 3: Data Reduction and Evaluation	70 %	6/30/2015	Behind*
Task 4: Reporting	70 %	6/30/2016	Behind*

Status of Project Milestones

Milestone Description	Planned Date	Complete?	Actual Date
Identify candidate bridges	10/31/2010	Yes	01/31/2016
Develop finite element models of candidate bridges	02/28/2015	Yes	12/31/2015
Develop the field testing plan for candidate bridges	06/30/2015		Overdue
Conduct field testing on simple span bridges	10/31/2015		Overdue
Reduce data and compare with AASHTO method	02/29/2016		Overdue
Make recommendations and submit final report	06/30/2016		Overdue

Project Financial Status

FY	FY Budgeted	FY Spent	Cumulative Budgeted	Cumulative Spent	Cumulative Balance
2011	$15,000.00	$5,000.00	$15,000.00	$5,000.00	$10,000.00
2012	$70,000.00	$20,000.00	$85,000.00	$25,000.00	$60,000.00
2013	$0.00	$20,547.00	$85,000.00	$45,547.00	$39,453.00
2014	$0.00	$13,589.00	$85,000.00	$59,136.00	$25,864.00
2015	$0.00	$2,750.00	$85,000.00	$61,886.00	$23,114.00
2016	$0.00	$5,823.90	$85,000.00	$67,709.90	$17,290.10
2017	$0.00	$297.48	$85,000.00	$68,007.38	$16,992.62

Billed this Quarter -- $297.48

Work Accomplished This Quarter

Load rating of bridge (047B00080N) in KYTC D04 was started.

Problems Encountered / Explanation for Any Tasks Behind Schedule

Delay due to equipment and bridge identification for load testing. Work Plan requires modification.

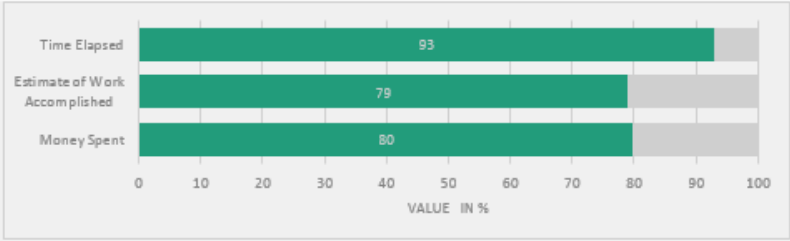


Figure B-12 An example quarterly progress report.

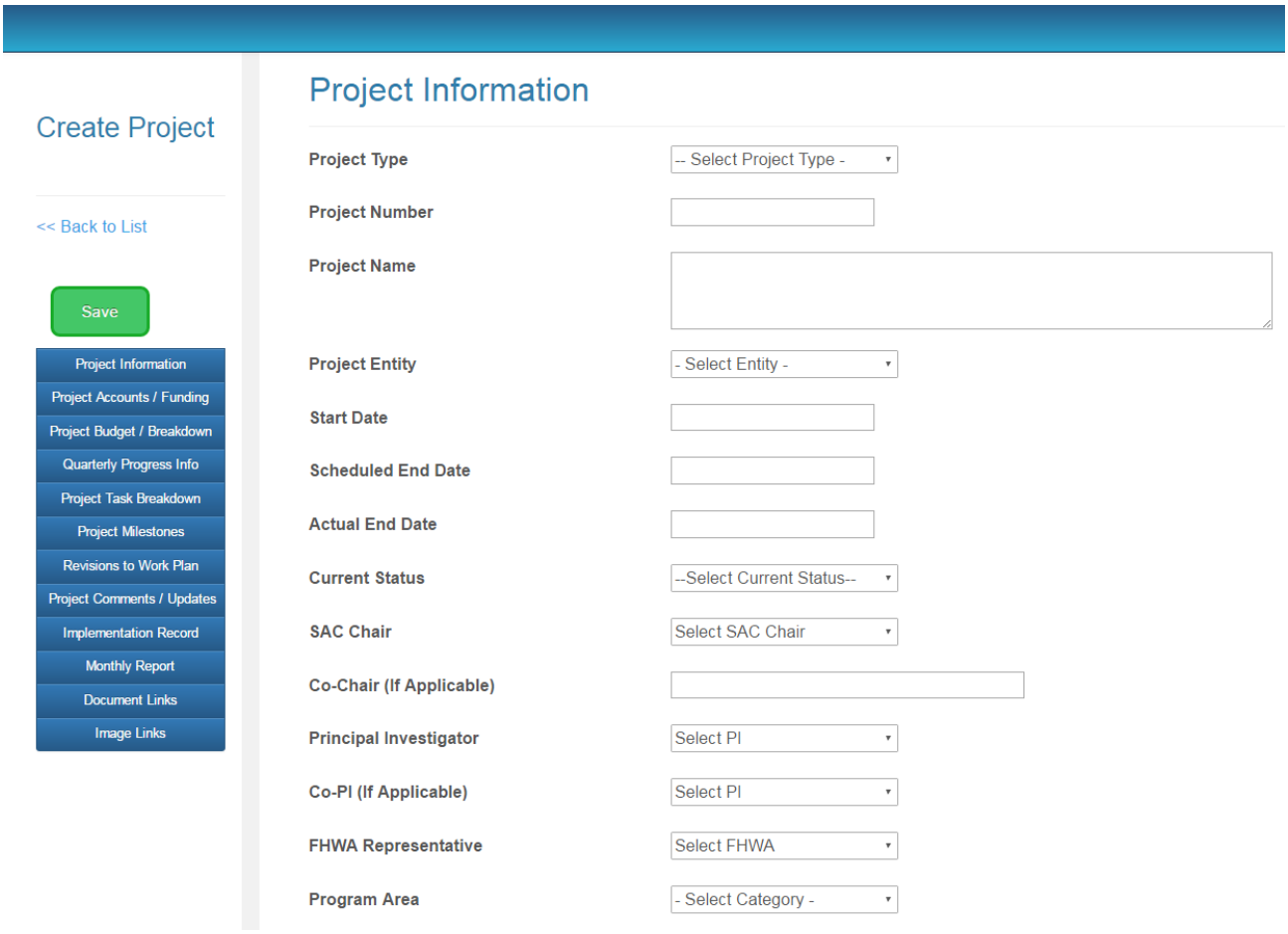


Figure B-13 Clicking on "Create Project" on the List of Projects screen will bring up this screen. The layout of this screen is virtually identical to the "Edit Project" screen. Filling in the data and clicking on "Save" creates a new project in the database.